Title: A MOSFET WITH A THIN
GATE INSULATING FILM
Inventor(s): Hisayo MOMOSE et al
DOCKET NO.: 016887-1094

FIG. 1

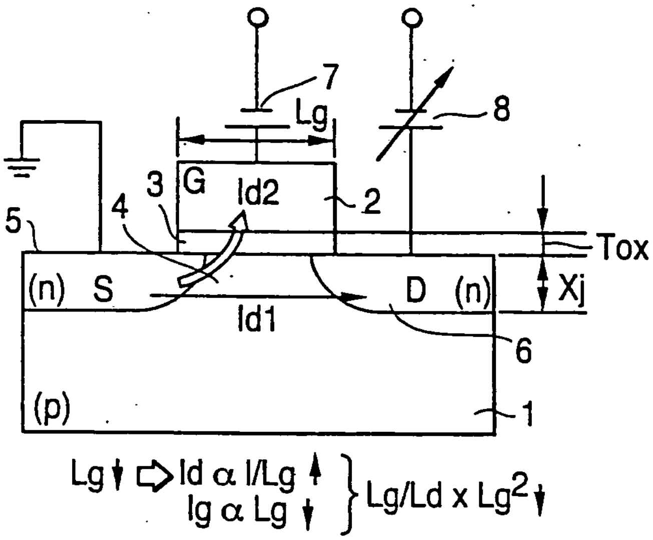
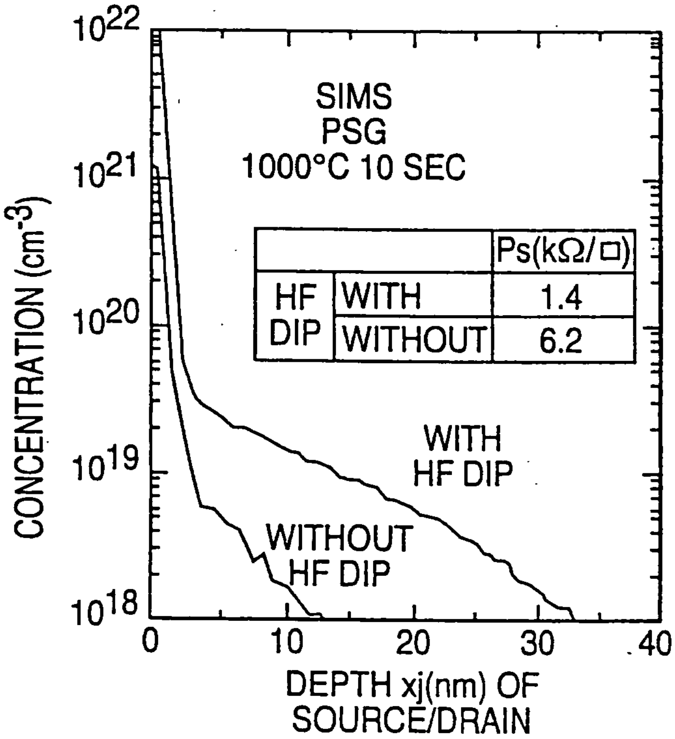


FIG. 2



		Ps(kΩ/□)
HF DIP	WITH	1.4
	WITHOUT	6.2

CONCENTRATION PROFILE TO
DIFFUSION DEPTH AT SOURCE/DRAIN REGION

FIG. 3

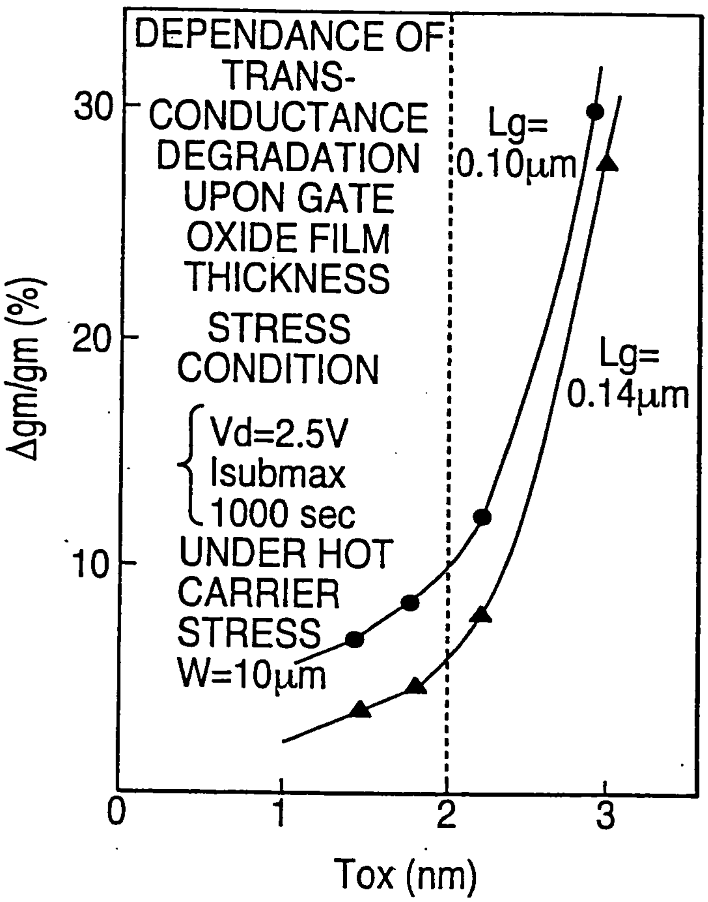

DEPENDANCE OF TRANS-CONDUCTANCE DEGRADATION UPON GATE OXIDE FILM THICKNESS
STRESS CONDITION
Vd=2.5V
Isubmax
1000 sec
UNDER HOT CARRIER STRESS
W=10μm
Lg= 0.10μm
Lg= 0.14μm
Δgm/gm (%)
30
20
10
0
1
2
3
Tox (nm)

FIG. 4

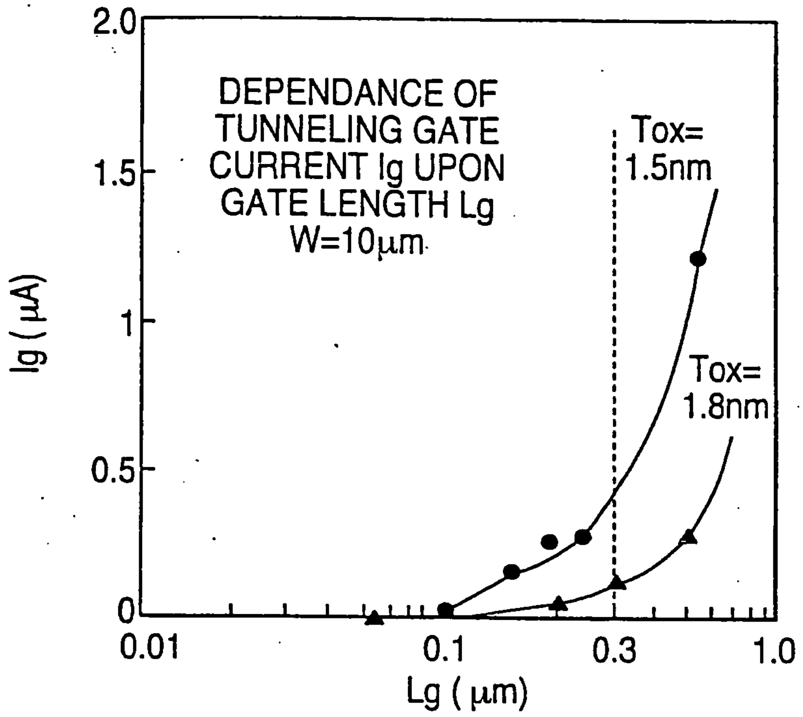

DEPENDANCE OF TUNNELING GATE CURRENT Ig UPON GATE LENGTH Lg
W=10μm
Tox=
1.5nm
Tox=
1.8nm
2.0
1.5
1
0.5
0
Ig (μA)
0.01
0.1
0.3
1.0
Lg (μm)

FIG. 5

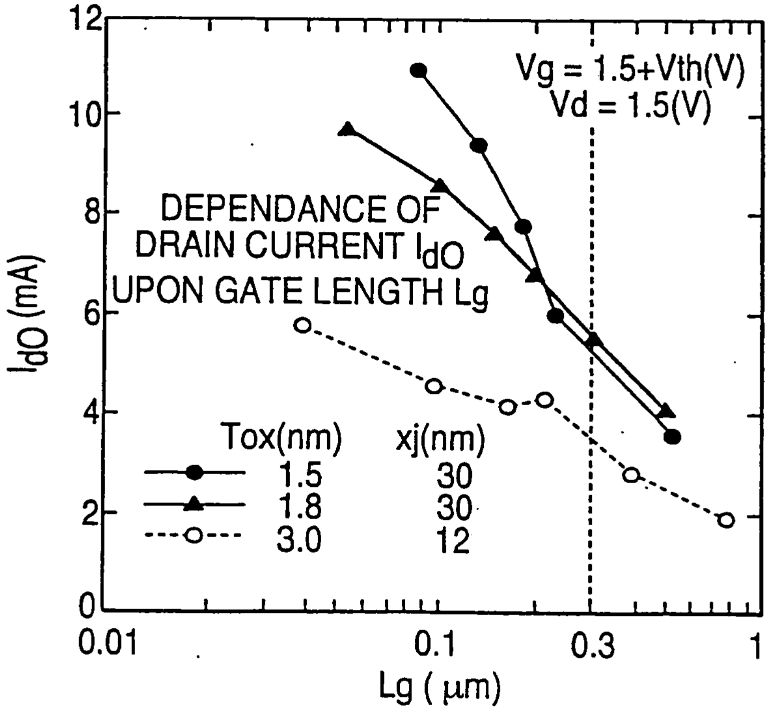

Vg = 1.5+Vth(V)
Vd = 1.5(V)
DEPENDANCE OF DRAIN CURRENT IdO UPON GATE LENGTH Lg
Tox(nm) xj(nm)
●— 1.5 30
▲— 1.8 30
○--- 3.0 12
12
10
8
6
4
2
0
IdO (mA)
0.01
0.1
0.3
1
Lg (μm)

FIG. 6

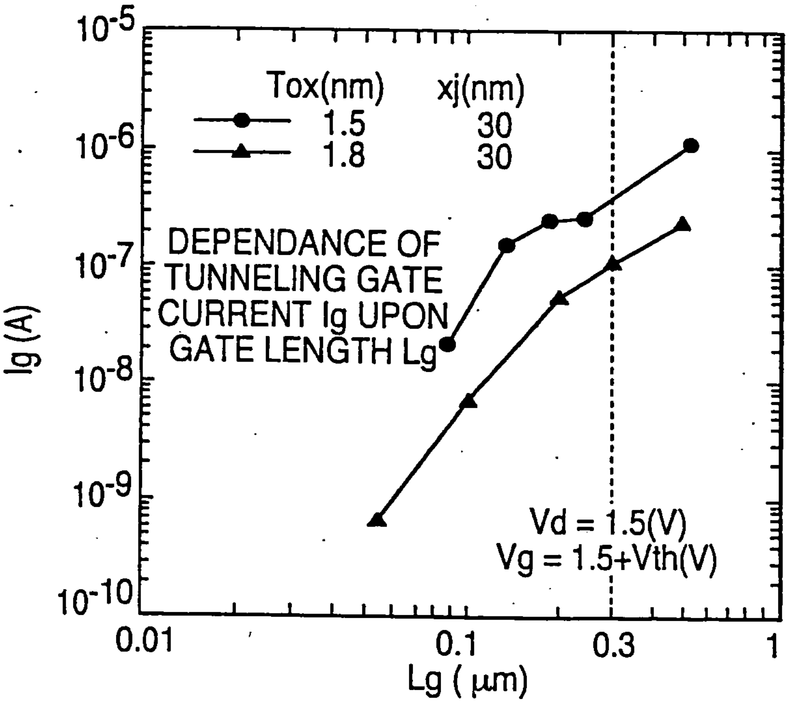
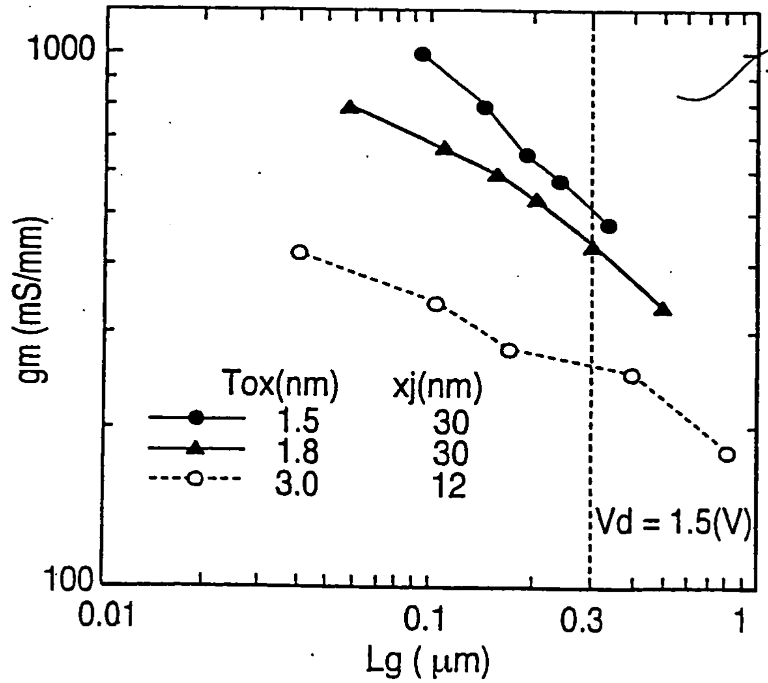


FIG. 7



DEPENDANCE OF TRANSCONDUCTANCE gm UPON GATE LENGTH Lg

FIG. 8A

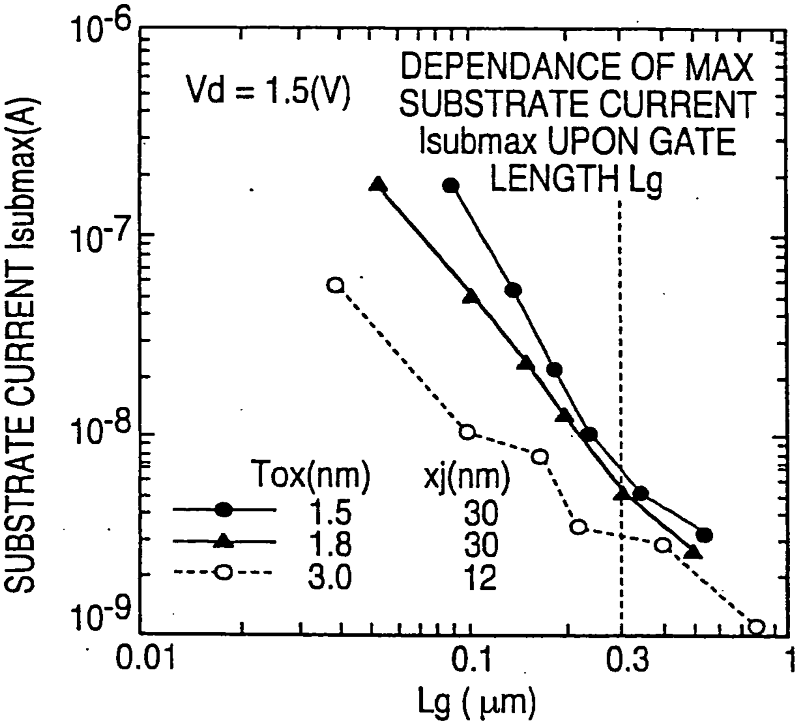

Vd = 1.5(V)
DEPENDANCE OF MAX SUBSTRATE CURRENT Isubmax UPON GATE LENGTH Lg
SUBSTRATE CURRENT Isubmax(A)
10-6
10-7
10-8
10-9
Tox(nm) xj(nm)
1.5 30
1.8 30
3.0 12
0.01
0.1
0.3
1
Lg (μm)

FIG. 8B

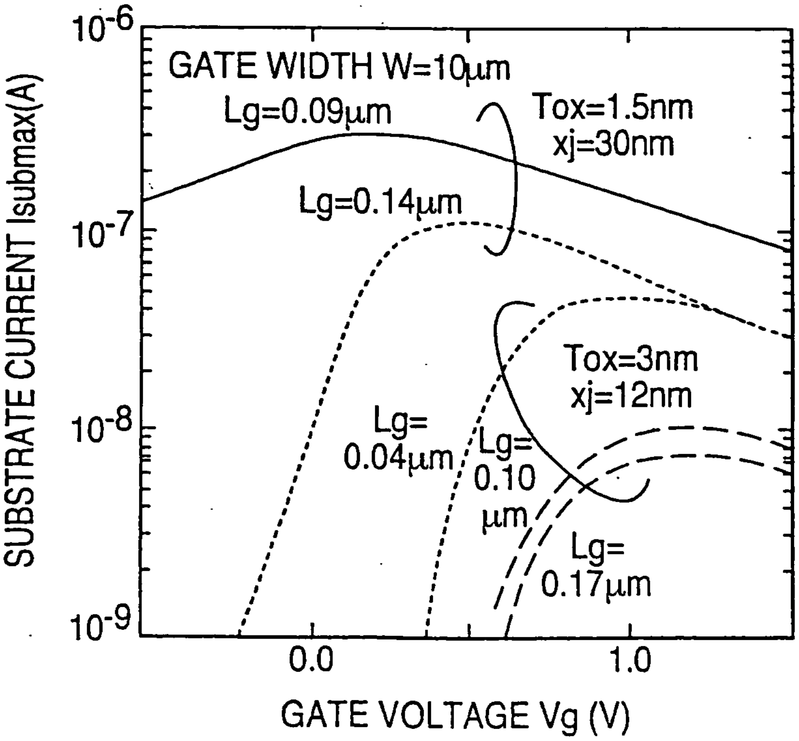

GATE WIDTH W=10μm
Lg=0.09μm
Tox=1.5nm
xj=30nm
Lg=0.14μm
Tox=3nm
xj=12nm
Lg= 0.04μm
Lg= 0.10 μm
Lg= 0.17μm
SUBSTRATE CURRENT Isubmax(A)
10-6
10-7
10-8
10-9
0.0
1.0
GATE VOLTAGE Vg (V)

FIG. 9

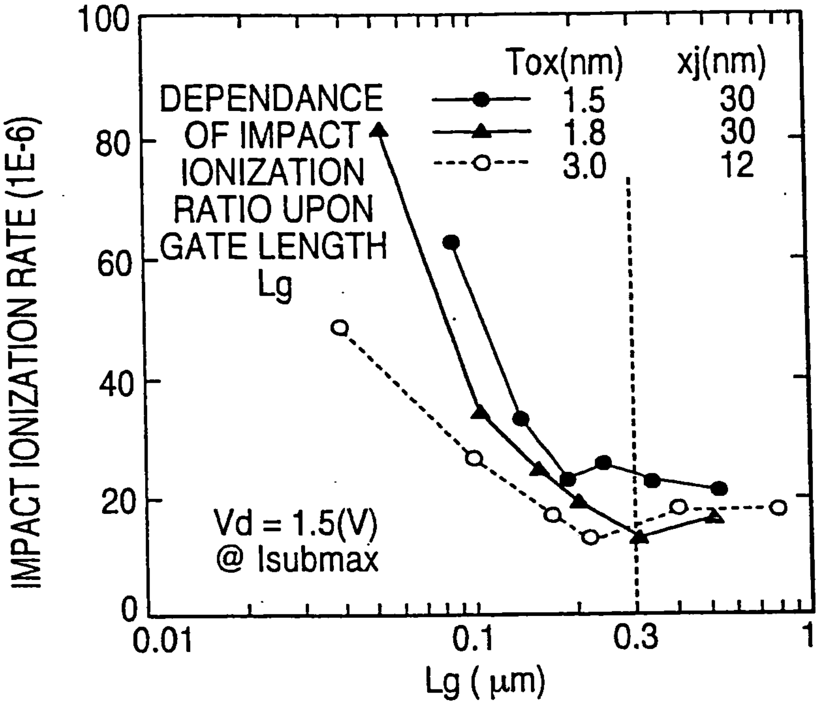
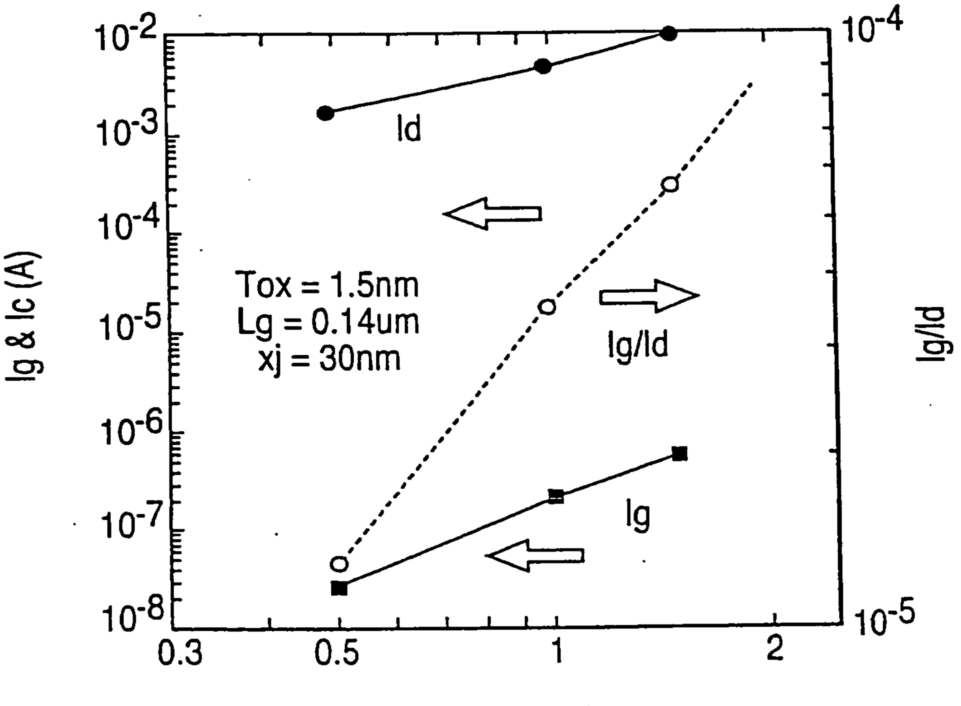


FIG. 10



DEPENDANCE OF CURRENT Ig
AND Id UPON SUPPLY VOLTAGE Vd = Vg

FIG. 11

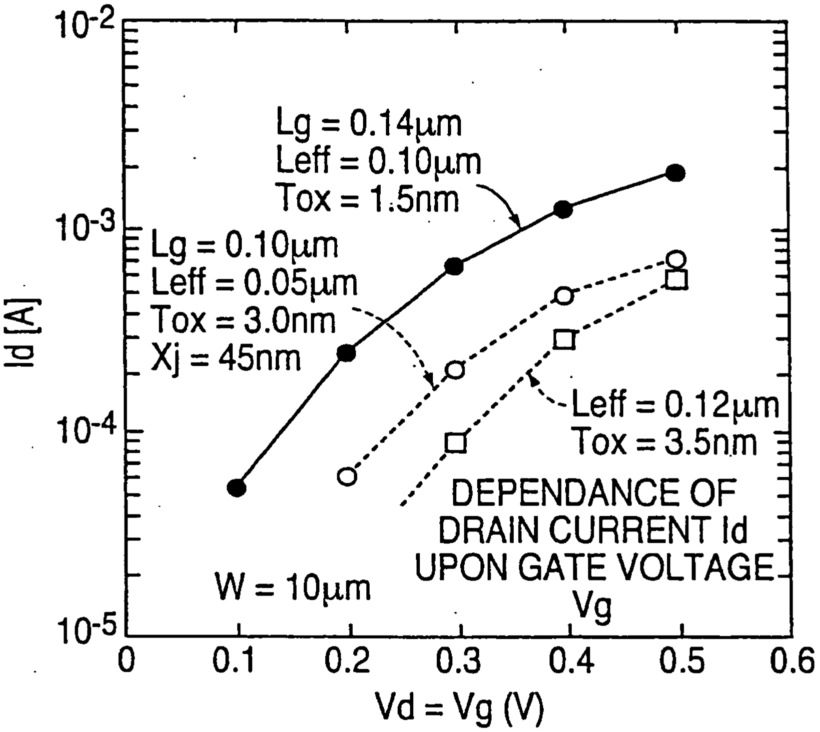

10^{-2}
10^{-3}
10^{-4}
10^{-5}
Id [A]
Lg = 0.14μm
Leff = 0.10μm
Tox = 1.5nm
Lg = 0.10μm
Leff = 0.05μm
Tox = 3.0nm
Xj = 45nm
Leff = 0.12μm
Tox = 3.5nm
DEPENDANCE OF
DRAIN CURRENT Id
UPON GATE VOLTAGE
Vg
W = 10μm
0
0.1
0.2
0.3
0.4
0.5
0.6
Vd = Vg (V)

FIG. 12

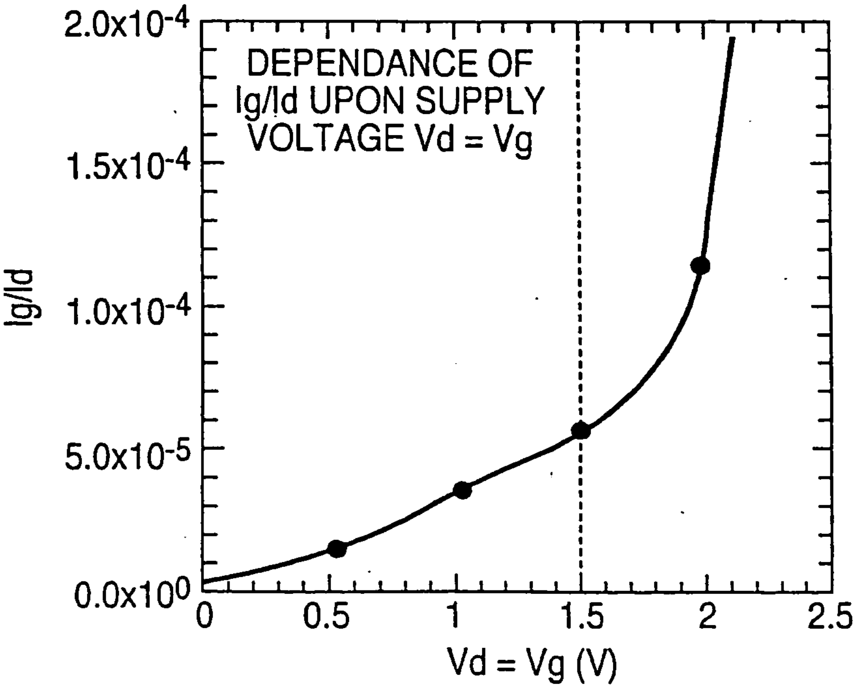
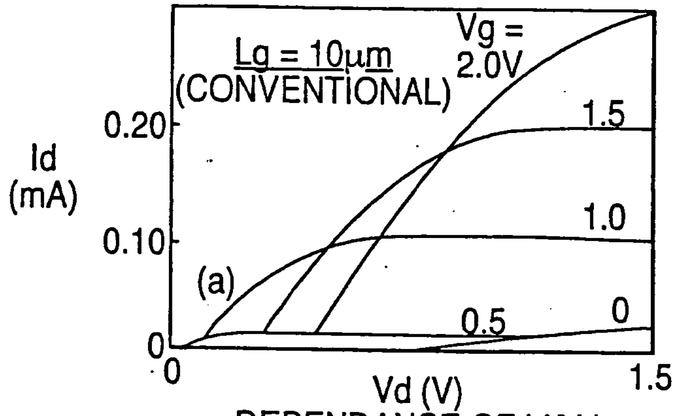
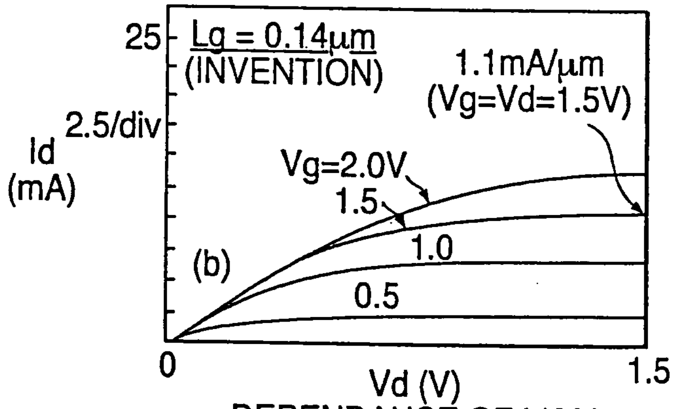

$2.0x10^{-4}$
$1.5x10^{-4}$
$1.0x10^{-4}$
$5.0x10^{-5}$
$0.0x10^{0}$
Ig/Id
DEPENDANCE OF
Ig/Id UPON SUPPLY
VOLTAGE Vd = Vg
0
0.5
1
1.5
2
2.5
Vd = Vg (V)

FIG. 13A



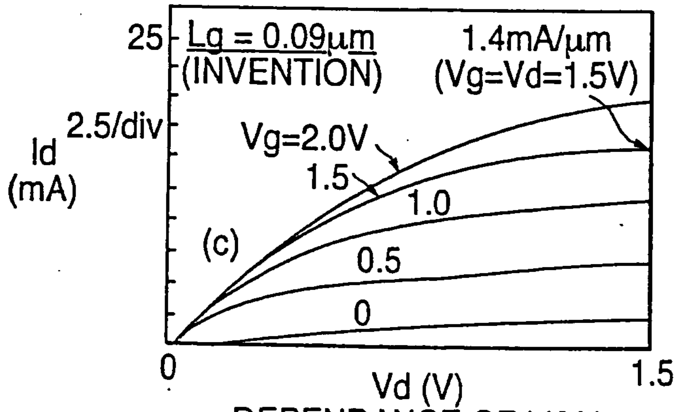
DEPENDANCE OF Id/Vd
UPON GATE VOLTAGE Vg

FIG. 13B



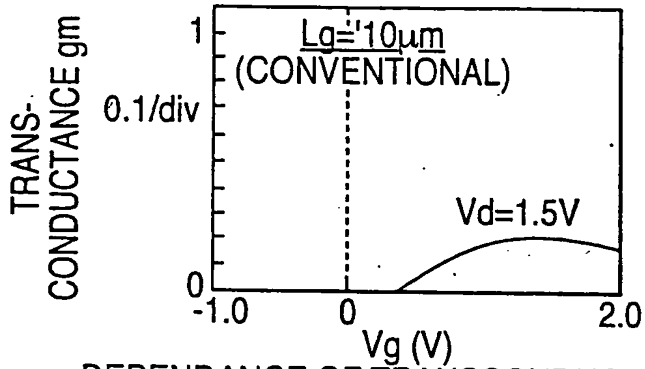
DEPENDANCE OF Id/Vd
UPON GATE VOLTAGE Vg

FIG. 13C



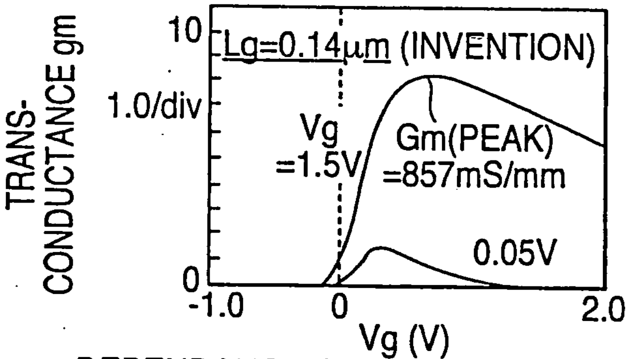
DEPENDANCE OF Id/Vd
UPON GATE VOLTAGE Vg

FIG. 14A



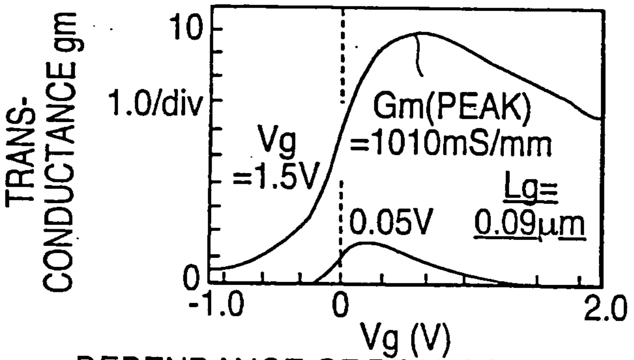
DEPENDANCE OF TRANSCONDUCTANCE gm UPON GATE VOLTAGE

FIG. 14B



DEPENDANCE OF TRANSCONDUCTANCE gm UPON GATE VOLTAGE

FIG. 14C



DEPENDANCE OF TRANSCONDUCTANCE gm UPON GATE VOLTAGE

FIG. 15A

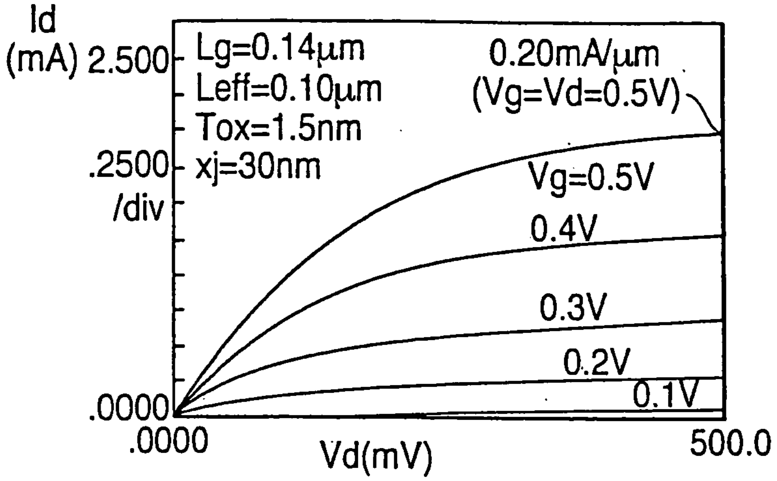


FIG. 15B

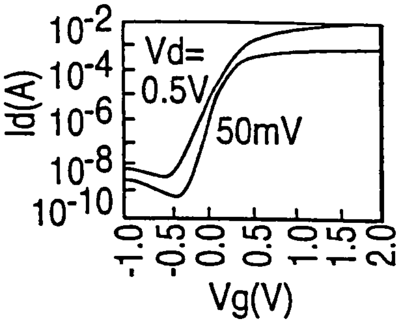


FIG. 15C

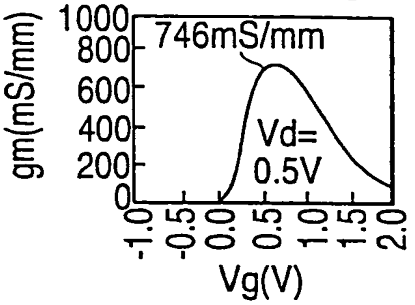


FIG. 15D
(PRIOR ART)

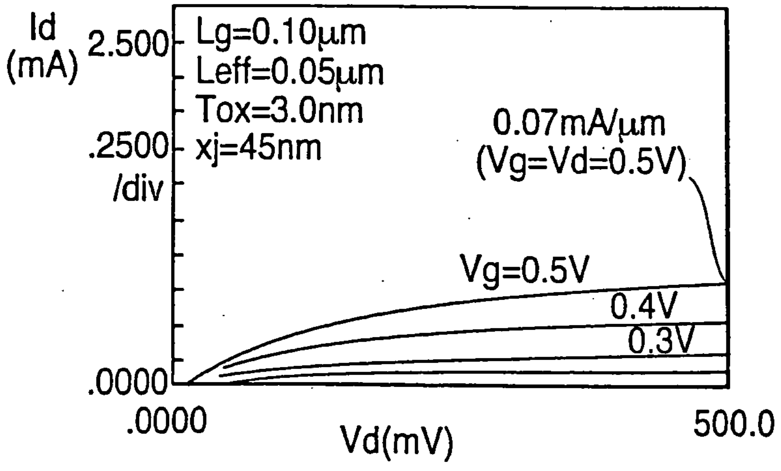


FIG. 15E
(PRIOR ART)

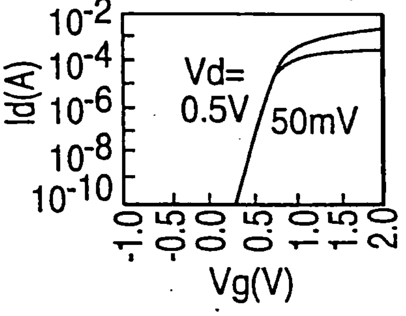


FIG. 15F
(PRIOR ART)

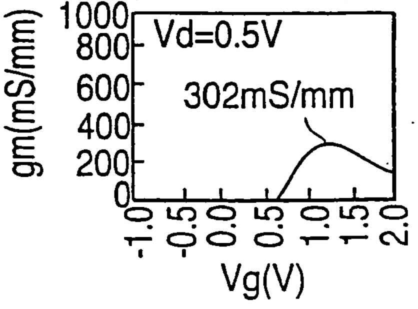
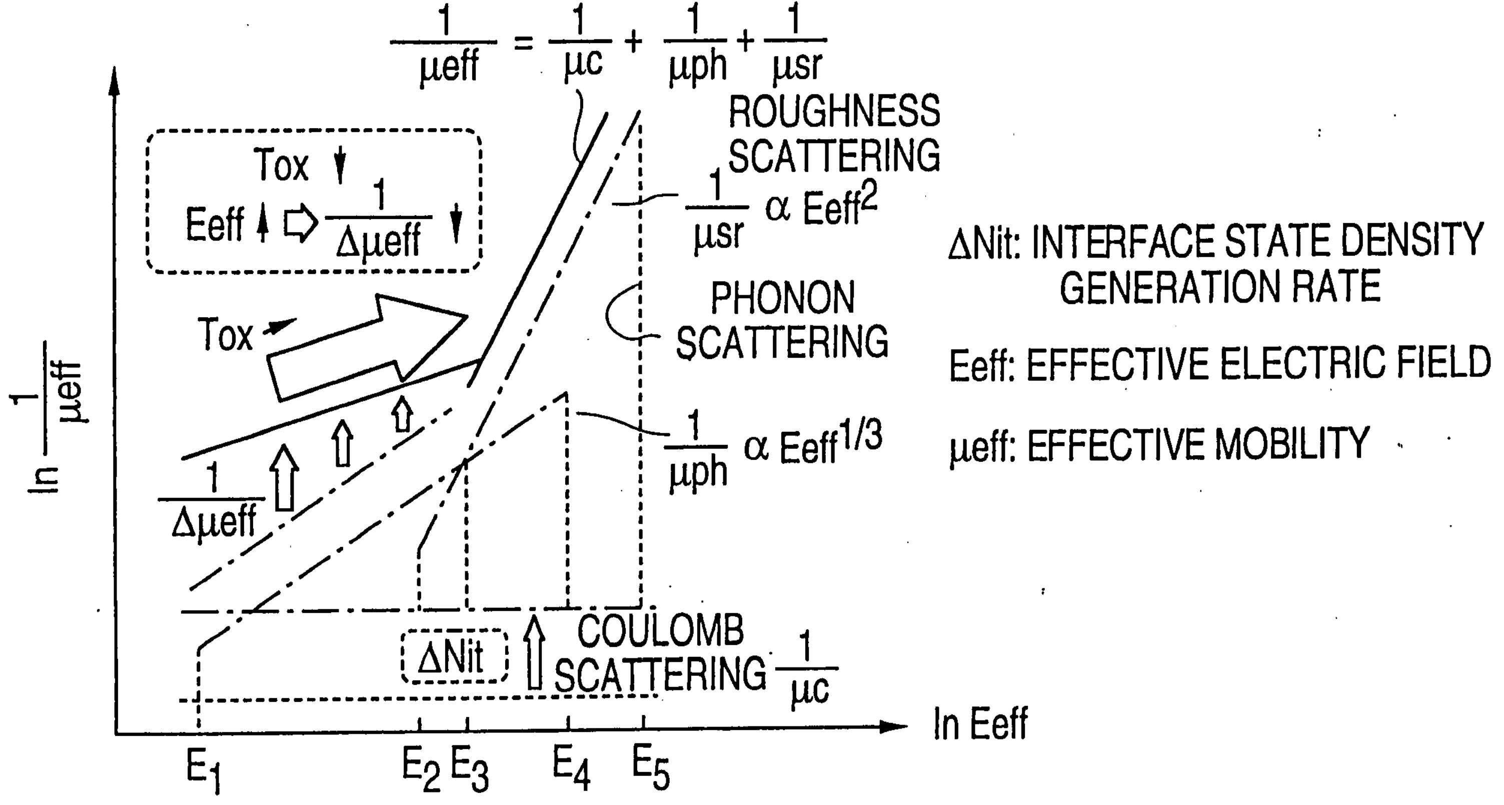


FIG. 16


$\frac{1}{\mu eff} = \frac{1}{\mu c} + \frac{1}{\mu ph} + \frac{1}{\mu sr}$
ROUGHNESS SCATTERING
$\frac{1}{\mu sr} \alpha Eeff^2$
PHONON SCATTERING
$\frac{1}{\mu ph} \alpha Eeff^{1/3}$
Tox ↓
Eeff ↑ ⇨ $\frac{1}{\Delta\mu eff}$ ↓
Tox
$\frac{1}{\Delta\mu eff}$
ΔNit
COULOMB SCATTERING $\frac{1}{\mu c}$
$\ln \frac{1}{\mu eff}$
ln Eeff
E_1
E_2
E_3
E_4
E_5
ΔNit: INTERFACE STATE DENSITY GENERATION RATE
Eeff: EFFECTIVE ELECTRIC FIELD
μeff: EFFECTIVE MOBILITY

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DOCKET NO.: 016887-1094

FIG. 17

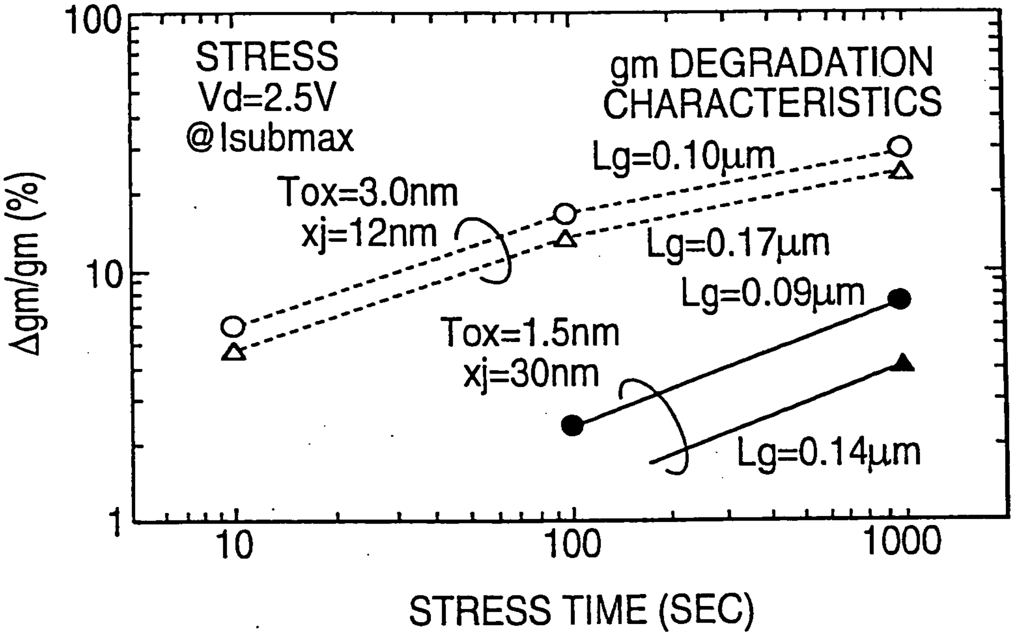

FIG. 18A

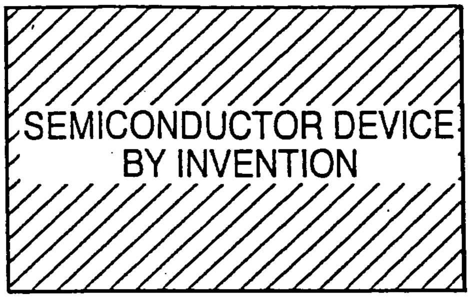

FIG. 18B

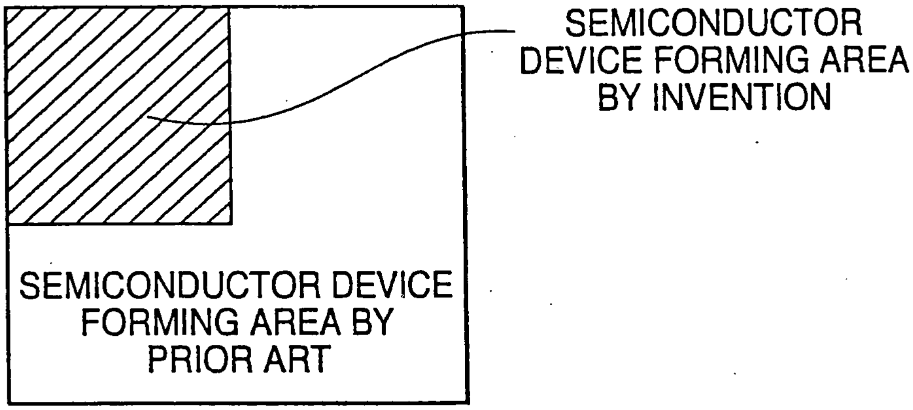

FIG. 18C

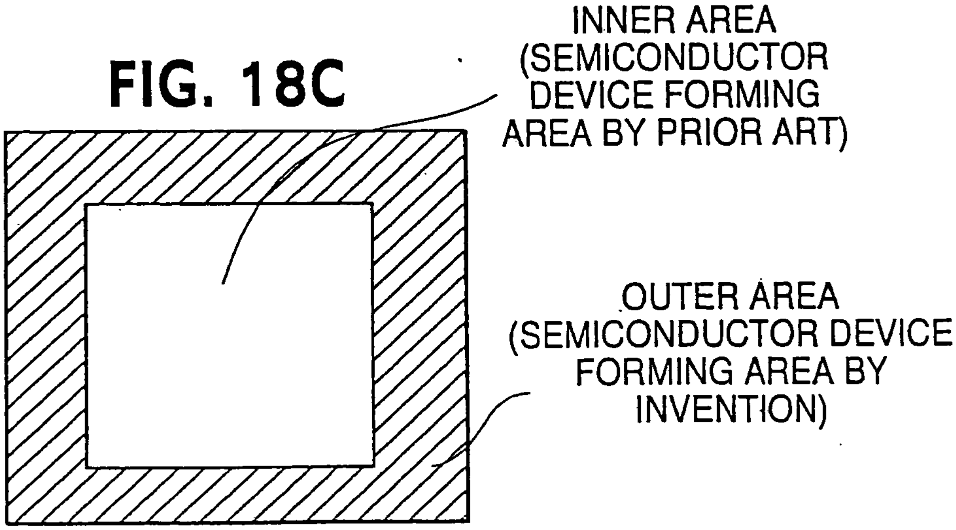

FIG. 19

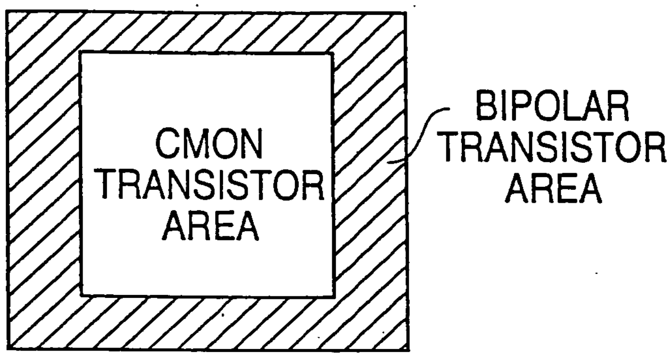
CMON
TRANSISTOR
AREA
BIPOLAR
TRANSISTOR
AREA

FIG. 20

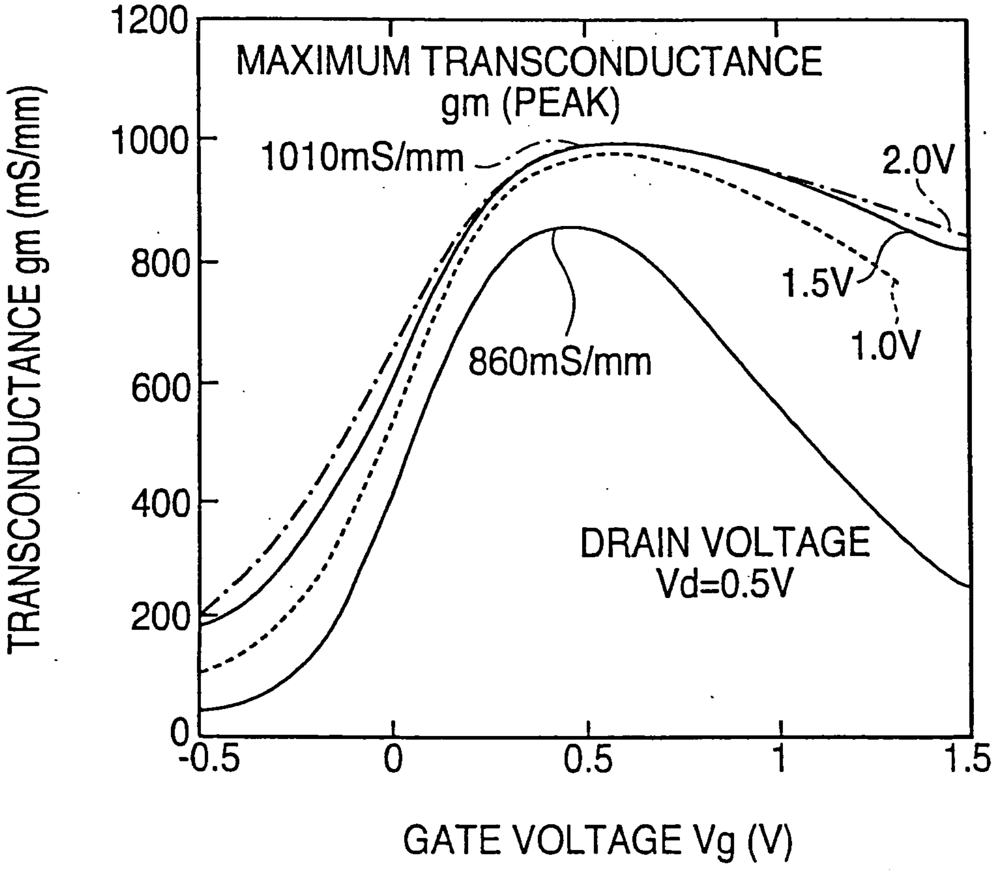
MAXIMUM TRANSCONDUCTANCE
gm (PEAK)
1010mS/mm
860mS/mm
2.0V
1.5V
1.0V
DRAIN VOLTAGE
Vd=0.5V
TRANSCONDUCTANCE gm (mS/mm)
1200
1000
800
600
400
200
0
-0.5
0
0.5
1
1.5
GATE VOLTAGE Vg (V)

FIG. 21

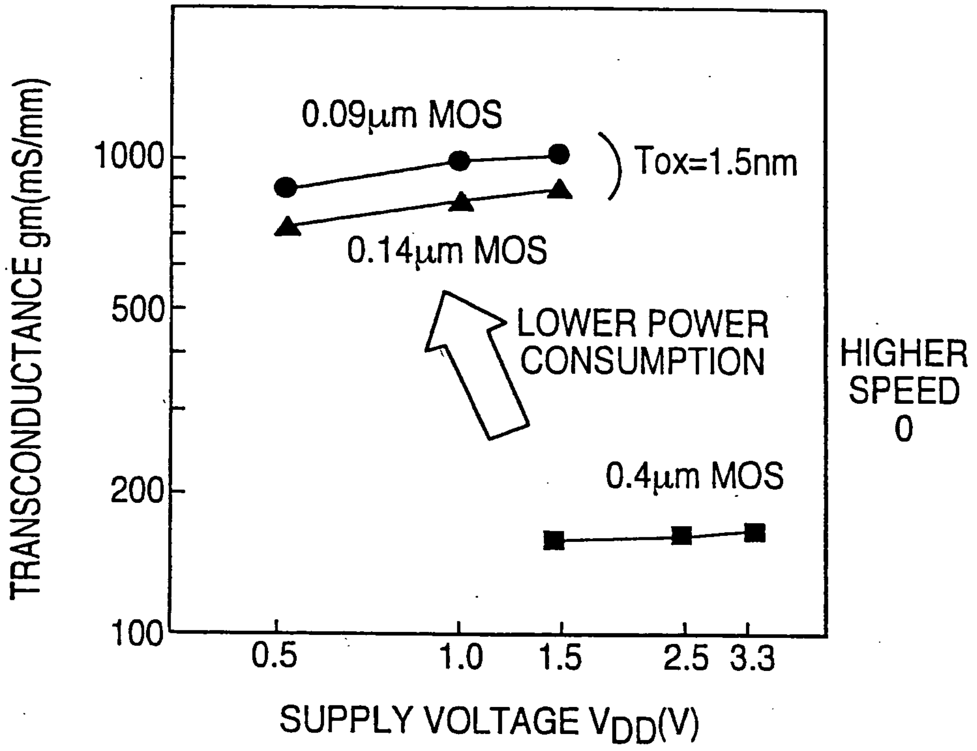
TRANSCONDUCTANCE gm(mS/mm)
1000
500
200
100
0.09μm MOS
Tox=1.5nm
0.14μm MOS
LOWER POWER CONSUMPTION
HIGHER SPEED
0
0.4μm MOS
0.5
1.0
1.5
2.5
3.3
SUPPLY VOLTAGE V_{DD}(V)

FIG. 22

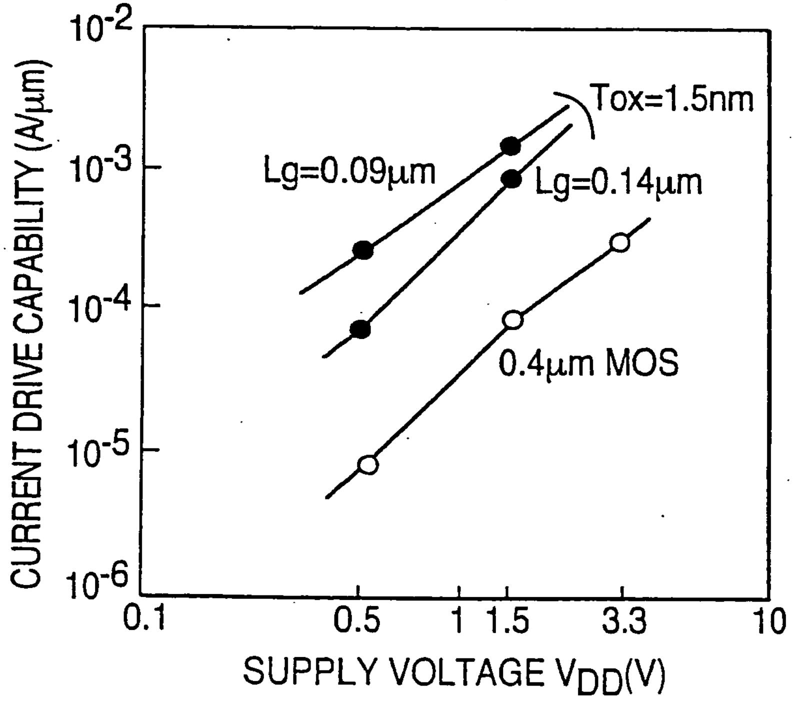
CURRENT DRIVE CAPABILITY (A/μm)
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
Tox=1.5nm
Lg=0.09μm
Lg=0.14μm
0.4μm MOS
0.1
0.5
1
1.5
3.3
10
SUPPLY VOLTAGE V_{DD}(V)

FIG. 23

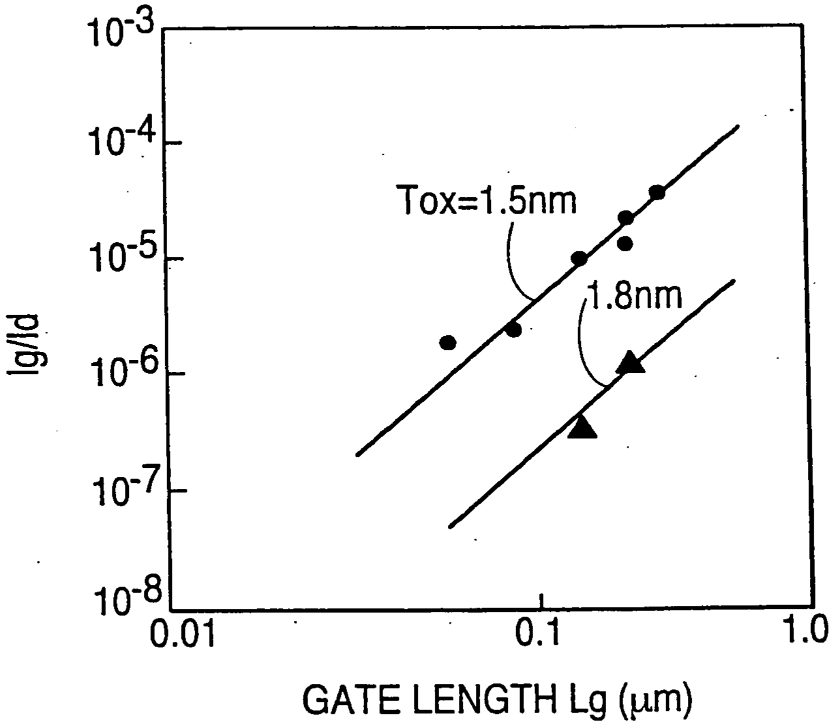
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
Ig/Id
Tox=1.5nm
1.8nm
0.01
0.1
1.0
GATE LENGTH Lg (μm)

FIG. 24A

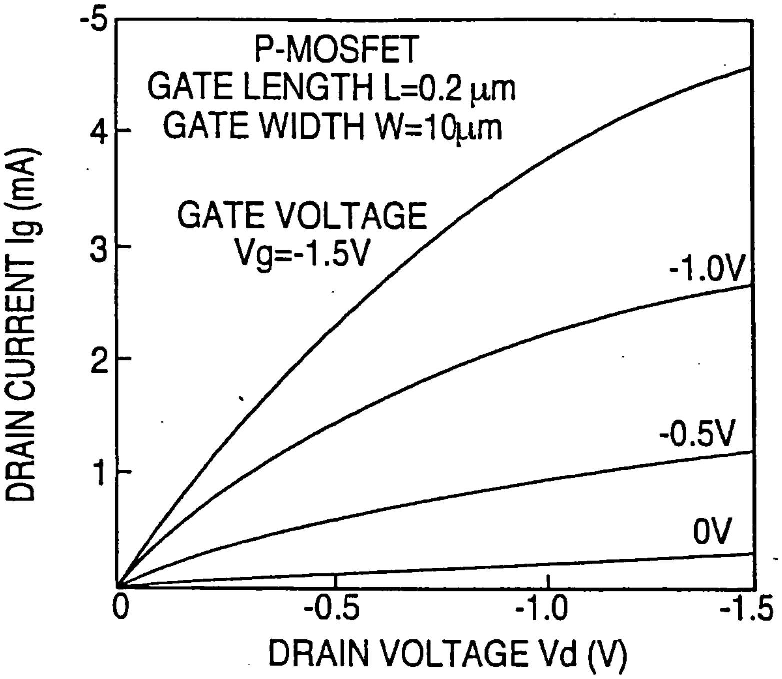

FIG. 24B

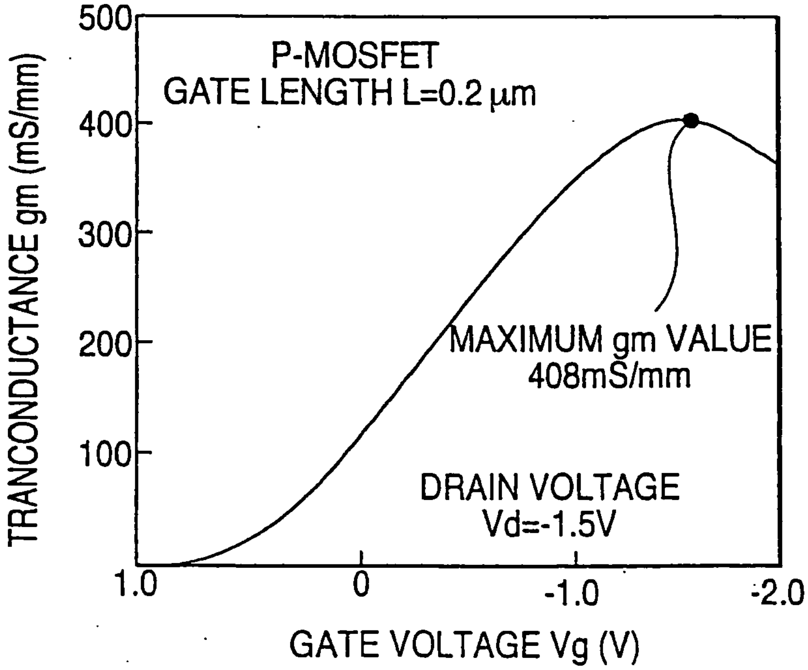

FIG. 25A

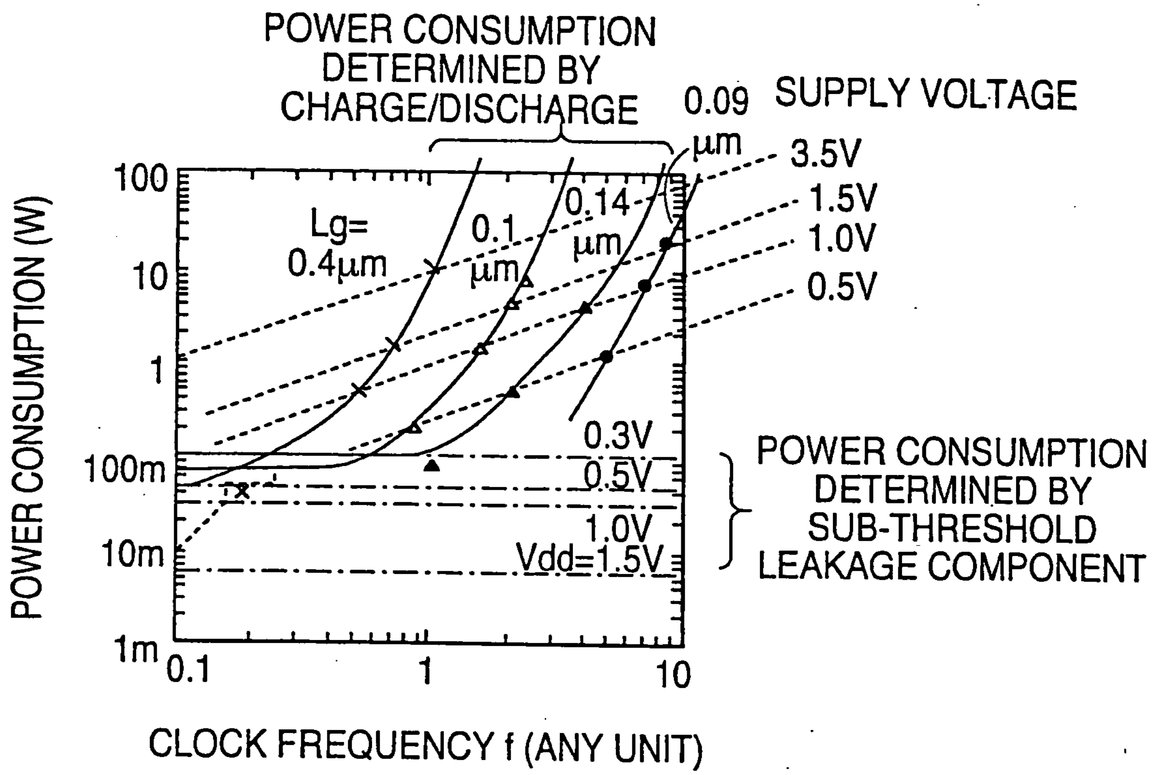

FIG. 25B

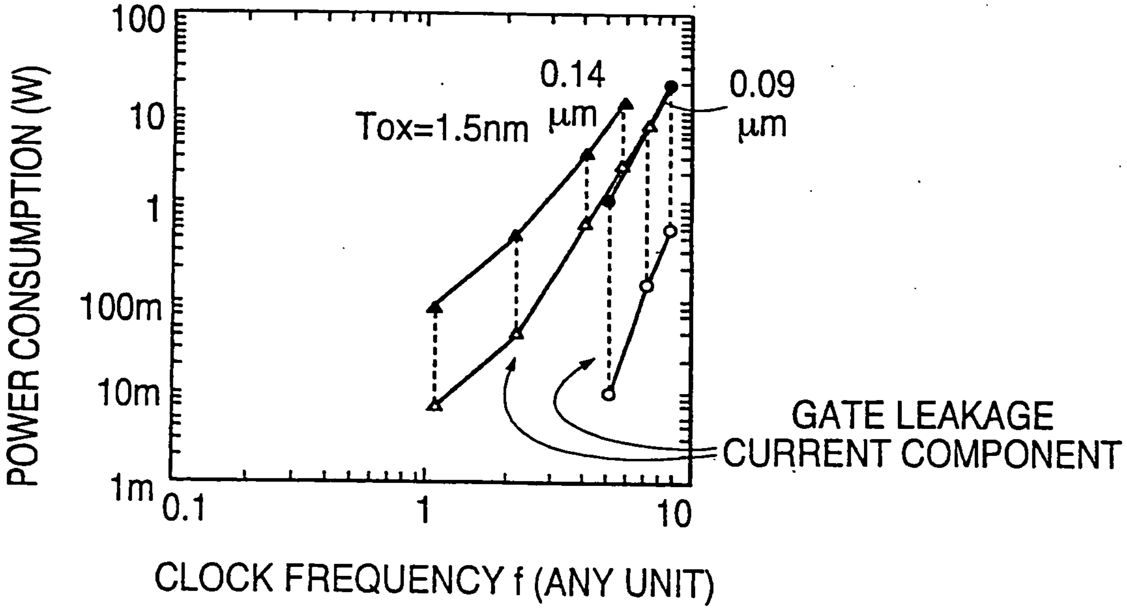

FIG. 26

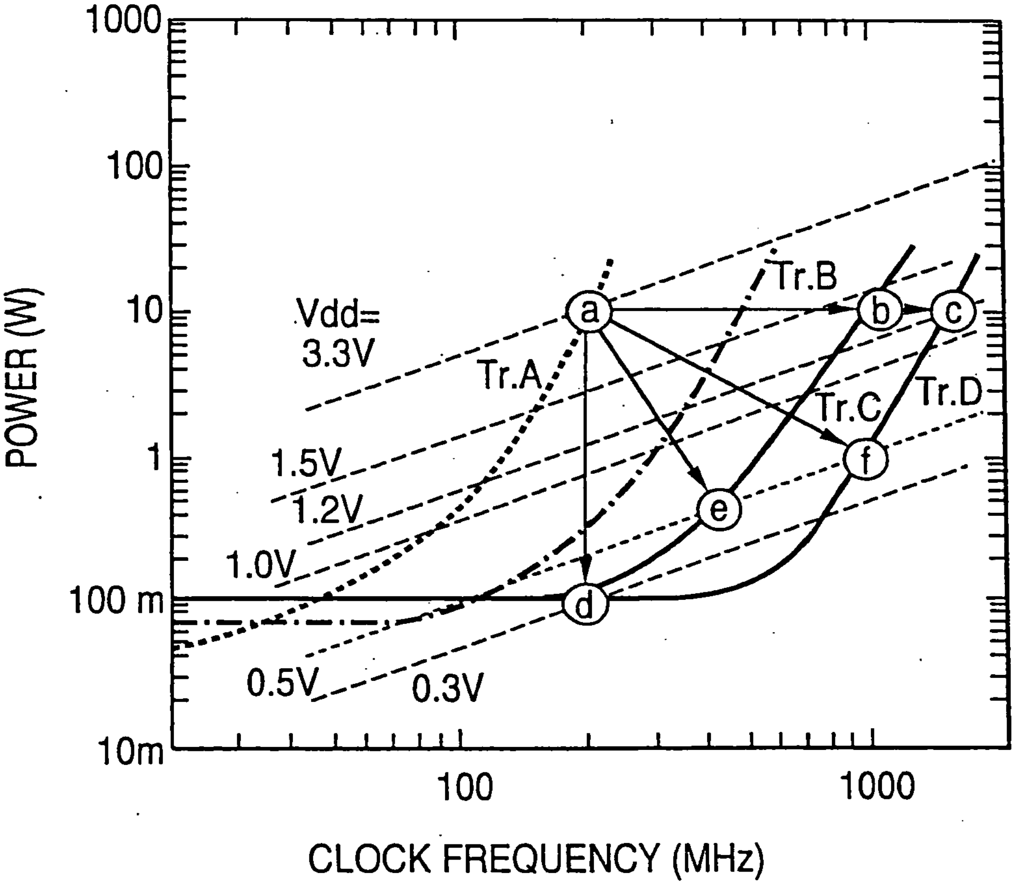
1000
100
10
1
100 m
10m
POWER (W)
100
1000
CLOCK FREQUENCY (MHz)
Vdd=
3.3V
1.5V
1.2V
1.0V
0.5V
0.3V
Tr.A
Tr.B
Tr.C
Tr.D
a
b
c
d
e
f

FIG. 27A

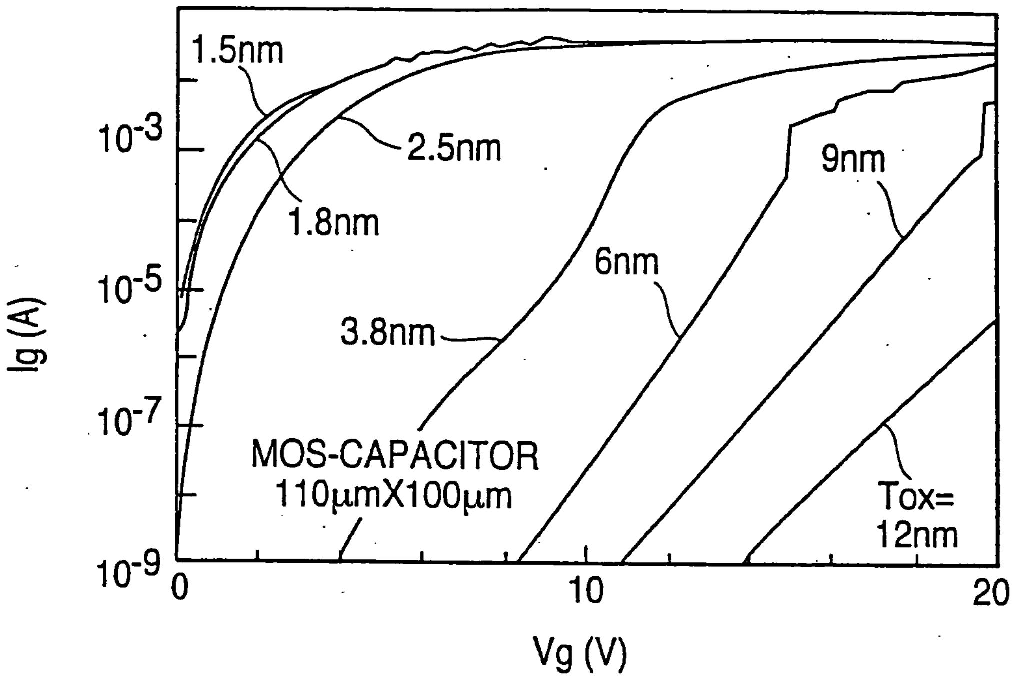

FIG. 27B

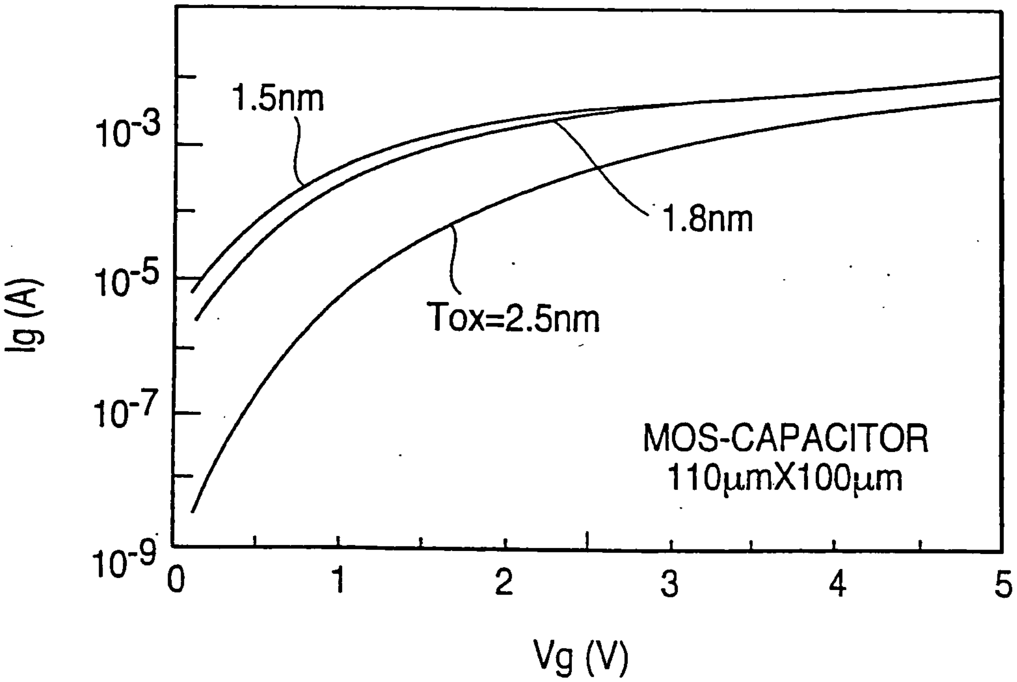

FIG. 28A

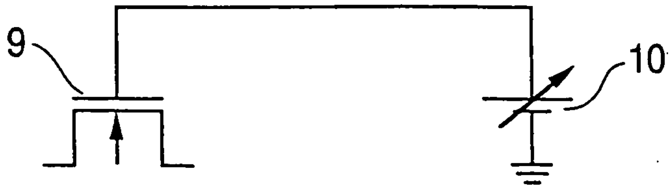

FIG. 28B

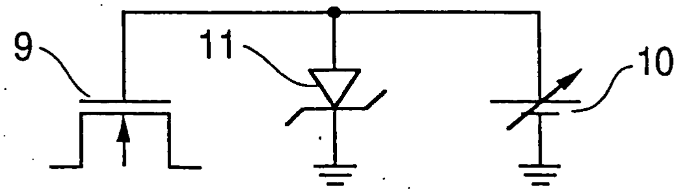

FIG. 29

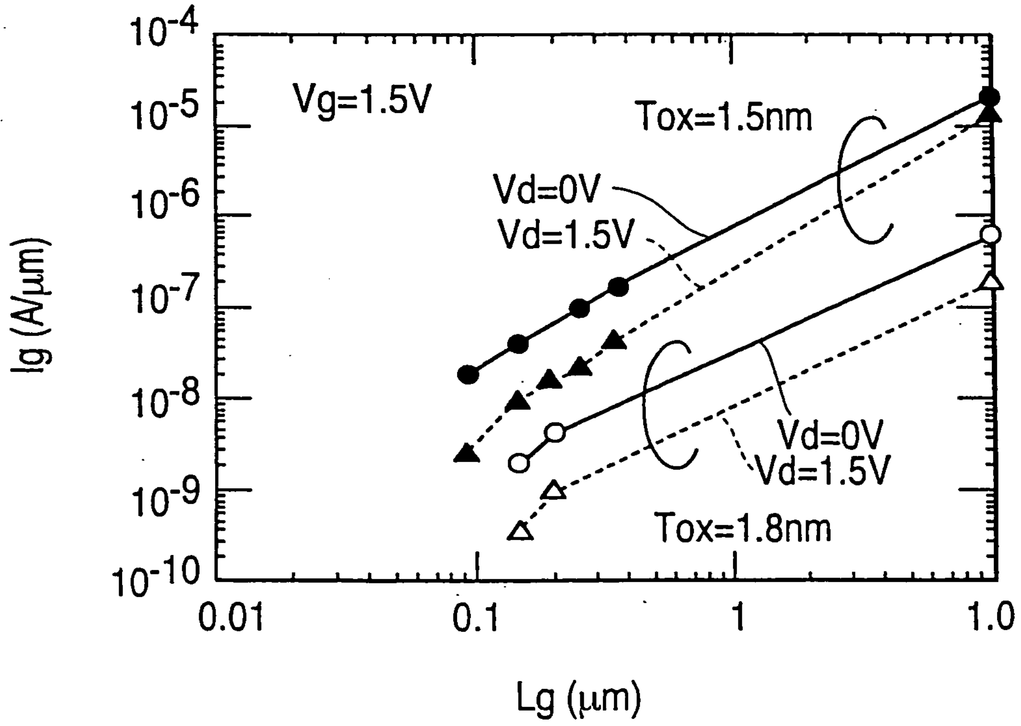

FIG. 30A

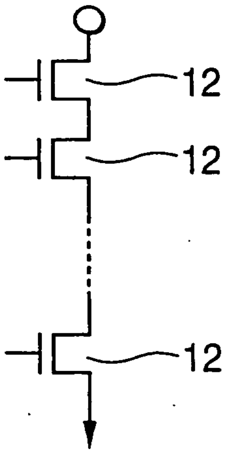

FIG. 30B